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(PCT Rule 61.2)

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Applicant PRESTON, John, Meek et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

22 July 2000 (22.07.00)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

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IMPORTANT NOTIFICATION

International application No.:
PCT/GB99/04391International filing date (day/month/year)
30 December 1999 (30.12.99)

1. The following indications appeared on record concerning:

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2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

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3. Further observations, if necessary:

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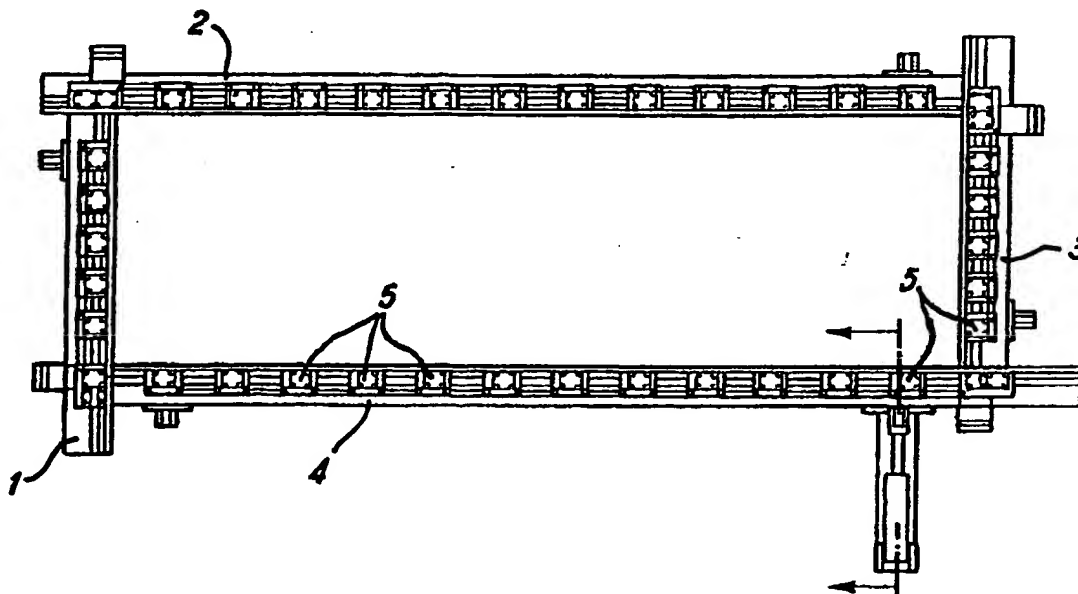
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM FORMING TECHNIQUES**(57) Abstract**

Machine and method for stretching and then vacuum forming acrylic sheets. Machine has clamping bars (1-4), each of which has a plurality of secondary clamps (5) which move along the clamping bars proportionately to the stretching of the plastic sheet as it stretches but act to prevent bowing of the plastic sheet. Primary clamps (13, 14) hold the edges of the sheet in place after stretching during the vacuum forming process.

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1 PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM
2 FORMING TECHNIQUES

3

4 The present invention relates in general to technology
5 for stretching plastic sheets. In particular, the
6 invention relates to the stretching of plastic sheets as
7 a preparation step for use with vacuum forming
8 techniques.

9

10 Vacuum forming techniques are used in a variety of
11 industries; for example, bathroom furnishings such as
12 baths can be vacuum formed from a single sheet of
13 thermoplastic material. The thermoplastic material most
14 commonly used for vacuum forming bathroom furnishings at
15 the present time is acrylic.

16

17 In this manufacturing process, the cost of the
18 thermoplastic sheet represents approximately 70% of the
19 manufacturer's final costs. It would therefore be
20 beneficial to find a method of using less thermoplastic
21 in the manufacturing process. However, if one simply
22 used a thinner sheet, one would expect to produce a final
23 product with reduced mechanical strength.

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1 It is therefore an aim of the present invention to
2 provide a method and apparatus for producing vacuum
3 formed goods that uses less thermoplastic than
4 conventional techniques whilst retaining, or even
5 improving, mechanical strength.

6
7 We have found that a thermoplastic sheet, such as an
8 acrylic sheet, which has been stretched before vacuum
9 forming provides a final product which has greater
10 mechanical strength than an unstretched sheet which has
11 the same thickness at the start of the vacuum forming
12 step.

13
14 However, when one considers how to implement this
15 stretching step industrially, a technical difficulty
16 becomes apparent. When a plastic sheet is stretched it
17 will scallop, that is to say that it will narrow in the
18 middle with the sides bowing inwards. This means that it
19 will not have a constant width and thickness throughout
20 and cannot be cut efficiently into smaller square or
21 rectangular portions.

22
23 For example, US Patent No. 5,271,352 to Critical Sciences
24 (Australia) Limited discloses a plastic stretching device
25 for use in vacuum forming boat hulls. This device pulls
26 plastic apart without any means for preventing
27 scalloping. It is therefore impractical to use for any
28 significant amount of stretching.

29
30 PCT/US92/07408 describes a plastic stretching device
31 which has movable clamping means holding all sides of a
32 plastic sheet. However, the edges of the plastic sheet
33 would be unable to expand with the material as a whole,
34 distorting its shape.

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1

2 JP60049921 to Toyota Jidosha KK goes part of the way to
3 solving this problem by having a plurality of clamps
4 along at least one side of a plastic sheet. However, the
5 movement of each clamps needs individually controlled,
6 leading to a complex and expensive machine.

7

8 In JP63197626 to Shinto Kogyo KK, a plurality of clamps
9 along opposite sides of a sheet of plastic are controlled
10 automatically by their being mounted on endless roller
11 chains which function to move the sheet of plastic into
12 and out of a heating means as well as holding the plastic
13 sheet. However, when material is stretched by this
14 machine moving the two roller chains apart, the material
15 edges held by the chains are unable to contract
16 proportionately, leading to distortion of the edges and
17 scalloping of the sheet as a whole.

18

19 The aim of this invention is therefore to provide a
20 method of stretching plastic sheets which can be used to
21 expand the total surface area of the sheet without
22 distorting the sheet, wasting material or having a non-
23 uniform thickness. In particular, the invention aims to
24 provide a simple controllable mechanism. Furthermore,
25 this invention aims to stretch the plastic sheet in a
26 manner adapted for immediate use in vacuum forming to
27 gain the strength enhancing benefits of the stretching
28 step.

29

30 In this application, the term "plastic" refers to any
31 thermoplastic material.

32

33 According to a first aspect of the present invention
34 there is provided a machine for stretching a rectangular

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4

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1 sheet of plastic material, the machine having a first and
2 second orthogonal pairs of opposed elongate clamping
3 means which engagably cooperate with the sides of said
4 sheet and thereby hold said sheet, the machine including
5 a means to controllably urge apart a first pair of
6 opposed elongate clamping means and thereby stretch a
7 sheet held therebetween characterized in that the second
8 pair of opposed elongate clamping means is adapted to
9 allow said sheet to stretch uniformly in a direction
10 parallel to the lengths of the second pair of elongate
11 clamping means whilst resisting movement of the clamped
12 sides of the sheet in a direction orthogonal to the
13 lengths of the second pair of elongate clamping means.
14

15 Preferably, the machine includes means to controllably
16 urge apart both pairs of opposed clamping means and
17 thereby stretch a sheet held therein in two dimensions,
18 each elongate clamping means being adapted to allow said
19 sheet to stretch uniformly in a direction parallel to the
20 length of said individual elongate clamping means whilst
21 resisting movement of the side of the rectangular sheet
22 clamped by said individual elongate clamping means in a
23 direction orthogonal to the length of said individual
24 elongate clamping means.
25

26 The machine may be adapted to stretch the sheet first in
27 one direction and then subsequently in a second direction
28 orthogonal to the first direction.
29

30 Preferably, the elongate clamping means having a
31 plurality of secondary clamps distributed along their
32 length, the secondary clamps engagably clamping a portion
33 of the edge of the rectangular sheet of plastic and being
34 adapted to move along the length of the elongate clamping

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1 means proportionately to the stretching of the sheet
2 parallel to the length of the clamping means.

3

4 More preferably, the secondary clamps are moved along the
5 length of the elongate clamping means by the motion of
6 the sheet.

7

8 Preferably, the clamping means have a primary clamping
9 means which engageably and fixedly clamps a side of the
10 sheet of the plastic material.

11

12 Preferably also, the machine has a heating means for
13 evenly heating a plastic sheet held therein.

14

15 According to a second aspect of the present invention
16 there is provided a machine for stretching and vacuum
17 forming a rectangular sheet of plastic comprising a
18 machine for stretching a rectangular sheet of plastic as
19 claimed in any preceding Claim and an engagable vacuum
20 forming means, wherein the engagable vacuum forming means
21 is adapted to vacuum form a rectangular sheet of plastic
22 stretched by the machine for stretching a rectangular
23 sheet of plastic whilst said rectangular sheet of plastic
24 is still held within the elongate clamping means of the
25 machine for stretching a rectangular sheet of plastic.

26

27 Preferably, the machine has a means for selectively
28 cooling zones of the plastic sheet held therein.

29

30 According to a third aspect of the present invention,
31 there is provided a method of stretching a rectangular
32 sheet of plastic material, the method comprising the
33 steps of:

34

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1 (a) engagably holding the sides of said sheet; and
2 (b) stretching said sheet along a first axis of said
3 sheet whilst holding the sides of said sheet
4 parallel to the first axis so as to allow the sheet
5 to stretch proportionately along the first axis but
6 so as to resist deformation of the sides of said
7 sheet orthogonal to the first axis.

8
9 Preferably, the method further has the step of:

10 (c) stretching said sheet along a second axis of
11 said sheet whilst holding the sides of said sheet
12 parallel to the second axis so as to allow the sheet
13 to stretch proportionately along the second axis but
14 so as to resist deformation of the sides of said
15 sheet orthogonal to the second axis, the second axis
16 being orthogonal to the first axis.

17
18 Preferably, the method involves, simultaneous to
19 stretching said sheet parallel to a first axis, also
20 stretching said sheet along a second axis of said sheet
21 whilst holding the sides of said sheet parallel to the
22 second axis so as to allow the sheet to stretch
23 proportionately along the second axis but so as to resist
24 deformation of the sides of said sheet orthogonal to the
25 second axis, the second axis being orthogonal to the
26 first axis.

27
28 Preferably, the sides of said sheet are engageably held
29 by a first and second orthogonal pairs of elongate
30 clamping means which each engagably cooperate with a side
31 of said sheet through a plurality of secondary clamps.

32
33 Preferably also, the secondary clamps are adapted to move
34 along the length of the clamping means proportionately to

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1 the stretching of the sheet along an axis parallel to the
2 clamping means.

3

4 Most preferably, the secondary clamps wherein the
5 secondary clamps are moved along the length of the
6 elongate clamping means by the motion of the sheet.

7

8 Typically, the method will have the step of heating the
9 sheet of plastic material.

10

11 According to a fourth aspect of the present invention,
12 there is provided a method of stretching and vacuum
13 forming a rectangular sheet of plastic material
14 comprising the steps of stretching a rectangular sheet of
15 plastic according to a method as claimed in any of Claims
16 10 to 16 and then vacuum forming said stretched sheet of
17 plastic.

18

19 Preferably, the edges of said sheet are engagably held by
20 a plurality of primary clamping means before vacuum
21 forming.

22

23 Zones of the plastic material may be selectively cooled.

24

25 An example embodiment of the present invention will now
26 be illustrated with reference to the following figures in
27 which:

28 Figure 1 is a plan view of a plastic sheet
29 stretching machine;

30 Figure 2 is a cross-section through a plastic
31 stretching machine along line AA;

32 Figure 3 is a perspective view of a plastic
33 stretching machine according to the present
34 invention;

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Figure 4 is a table of results from a Notched Charpy Impact Strength test performed to BS EN ISO 179/1eA-1997; and

Figure 5 shows a plan for cutting up sheets of material in a conventional fashion and in a fashion for use with the present invention.

A plastic stretching machine shown in plan view in Figure 1 is intended for use with a rectangular sheet of plastic material or any other vacuum formable material. Elongate clamping means are provided in the form of four clamping bars (1 to 4), one to clamp each edge of the rectangular plastic sheet. Clamping bars 1 and 3 oppose each other, as do clamping bars 2 and 4. Clamping bars 1 and 2 are fixed in place, whereas clamping bars 3 and 4 may be moved, as controlled by a programmable logic controller.

Each clamping bar 1, 2, 3 and 4 comprises a plurality of secondary clamping means 5 (only some of which are labelled in Figure 1). These clamping means are mounted upon each clamp bar and may move along its length with a low co-efficient of friction.

A rectangular hot thermoplastic sheet is placed within the device and is clamped around its four edges by the secondary clamps 5. This apparatus is shown in cross-section along line AA in Figure 2. The machine may also have means to itself heat the sheet and/or keep the sheet hot.

Actuator 6 (one shown in detail as an example) activates the clamping mechanism. This causes the clamping head to be rotated around joint 7 on support assembly 8 and the plastic sheet is held in the secondary clamps 5 between

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1 plates 9 and 10. Alternate pairs of clamp bars are then
2 pulled apart. For example, whilst clamp bar 1 is held in
3 place, clamp bar 3 may be moved away from it, stretching
4 the plastic sheet in the longitudinal direction. Clamp
5 bars 2 and 4 do not move. However, the secondary clamps
6 5 are free to move along the clamp bars. They are pulled
7 along by the material sheet and therefore move
8 proportionately to the movement of clamp bar 3. They act
9 to resist scalloping of the plastic sheet.

10

11 Similarly, clamp bar 4 can be moved away from clamp bar
12 2, whilst clamp bar 1 and clamp bar 3 remain in place.
13 Again, the clamping means move proportionately to the
14 stretching of the sheet cause by movement in clamping bar
15 4 and prevent scalloping. In order for this to work
16 there has to be very low friction preventing the movement
17 of the secondary clamping means.

18

19 Once the stretching phase has been completed, an actuator
20 11 acting through a thrust pin 12 engages a primary
21 clamping means which is provided on each clamped set and
22 comprises a top plate 13 and bottom plate 14 within which
23 the plastic sheet is securely held. All four sides are
24 held at once.

25

26 A mould is then driven up through the clamped sheet
27 forming a seal. The mould is then vacuumed by
28 conventional means to form the resulting mould. At the
29 end of this complete product cycle the secondary clamp
30 carriages 5 are returned to their initial positions by
31 the action of the primary clamp bars. A series of
32 linkages prevent the secondary clamps 5 from getting too
33 close to each other.

34

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10.

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1 Figure 4 shows a perspective view of the combined
2 stretching and vacuum forming machine. In this Figure,
3 conventional vacuum forming apparatus 15 is provided
4 underneath the stretching apparatus. The machine also
5 provides zoned cooling for control of thickness
6 distribution in the final product. This is a technique
7 used in the prior art and cooling apparatus 16 is mounted
8 above the stretching apparatus. An electronic controller
9 17 is provided to allow automation of the procedure.

10

11 The entire process cycle involving both the timings and
12 movements is controlled by a computer or controlled
13 programme logic controller. As a result of this machine
14 it becomes possible to make considerable savings in raw
15 material costs; for example, experiments have indicated
16 that savings of 30% - 50% can be readily achieved. This
17 could not be achieved simply by vacuum forming a thinner
18 sheet of thermoplastic as only the strength benefits
19 provided by the stretching step allow this lower volume
20 of plastic to be used.

21

22 Figure 4 shows a table of results from a Notched Charpy
23 Impact Strength (N.C.I.S.) test performed to BS EN ISO
24 179/1eA - 1997 on samples of 5mm Acrylic Cappers ABS
25 taken through the above process.

26

27 In this table, Flexural Modulus tests were performed to
28 BS EN ISO 178 - 1997 at a test speed of 2mm/min. Sample
29 10 test bars were nominally 4mm thick x 10mm wide.
30 Sample 12 test bars nominally 2.3mm thick x 15mm wide.
31 Fallen Ball. All Notched Charpy samples that gave a
32 valid result exhibited a partial break type.

33

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1 Figure 5 (a) shows a conventional method for cutting up a
2 sheet of plastic that is 3100mm x 1800mm to form four
3 rectangular pieces 1750mm x 750mm for use in making a
4 product sized 1700mm x 700mm. Note that offcuts are left
5 around the edge. Figure 5 (b) shows how this same sheet
6 can be cut into six rectangular pieces 1550mm x 600mm
7 without offcuts, that may be stretched then used to give
8 a product sized 1700mm x 700mm as before.

9

10 This reduces the time required and the space requirements
11 for storing raw material. Additionally, fewer different
12 sizes of sheet will have to be stocked by a manufacturer.
13 These benefits represent a substantial cut in the cost of
14 manufacturing the product, therefore providing an
15 important commercial advantage.

16

17 It will be clear to one skilled in the art that this
18 technique can be used with acrylic plastic or any other
19 vacuum formable material. Furthermore, this plastic
20 stretching technique will find applications in areas
21 other than just vacuum forming.

22

23 Further modifications and improvements may be
24 incorporated without departing from the scope of the
25 invention herein described.

26

27 Throughout this application, unless the context requires
28 otherwise, the word "comprise" or variations such as
29 "comprises" or "comprising" will be understood to imply
30 the inclusion of a stated integer or group of integers
31 but not the exclusion of any other integer or group of
32 integers.

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1 CLAIMS

2

3 1. A machine for stretching a rectangular sheet of
4 plastic material, the machine having a first and
5 second orthogonal pairs of opposed elongate clamping
6 means which engagably cooperate with the sides of
7 said sheet and thereby hold said sheet, the machine
8 including a means to controllably urge apart a first
9 pair of opposed elongate clamping means and thereby
10 stretch a sheet held therebetween characterized in
11 that the second pair of opposed elongate clamping
12 means is adapted to allow said sheet to stretch
13 uniformly in a direction parallel to the lengths of
14 the second pair of elongate clamping means whilst
15 resisting movement of the clamped sides of the sheet
16 in a direction orthogonal to the lengths of the
17 second pair of elongate clamping means.

18

19 2. A machine for stretching a rectangular sheet of
20 plastic material as Claimed in Claim 1, the machine
21 including means to controllably urge apart both
22 pairs of opposed clamping means and thereby stretch
23 a sheet held therein in two dimensions, each
24 elongate clamping means being adapted to allow said
25 sheet to stretch uniformly in a direction parallel
26 to the length of said individual elongate clamping
27 means whilst resisting movement of the side of the
28 rectangular sheet clamped by said individual
29 elongate clamping means in a direction orthogonal to
30 the length of said individual elongate clamping
31 means.

32

33 3. A machine for stretching a rectangular sheet of
34 plastic material as Claimed in Claim 1 or Claim 2,

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13

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1 the machine being adapted to stretch the sheet first
2 in one direction and then subsequently in a second
3 direction orthogonal to the first direction.
4

5 4. A machine for stretching a rectangular sheet of
6 plastic as claimed in any preceding Claim, the
7 elongate clamping means having a plurality of
8 secondary clamps distributed along their length, the
9 secondary clamps engagably clamping a portion of the
10 edge of the rectangular sheet of plastic and being
11 adapted to move along the length of the elongate
12 clamping means proportionately to the stretching of
13 the sheet parallel to the length of the clamping
14 means.
15

16 5. A machine for stretching a rectangular sheet of
17 plastic as claimed in Claim 4, wherein the secondary
18 clamps are moved along the length of the elongate
19 clamping means by the motion of the sheet.
20

21 6. A machine for stretching a rectangular sheet of
22 plastic as claimed in any preceding Claim, wherein
23 the clamping means have a primary clamping means
24 which engageably and fixedly clamps a side of the
25 sheet of the plastic material.
26

27 7. A machine for stretching a rectangular sheet of
28 plastic as claimed in any preceding Claim, the
29 machine having a heating means for evenly heating a
30 plastic sheet held therein.
31

32 8. A machine for stretching and vacuum forming a
33 rectangular sheet of plastic comprising a machine
34 for stretching a rectangular sheet of plastic as

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1 claimed in any preceding Claim and an engagable
2 vacuum forming means, wherein the engagable vacuum
3 forming means is adapted to vacuum form a
4 rectangular sheet of plastic stretched by the
5 machine for stretching a rectangular sheet of
6 plastic whilst said rectangular sheet of plastic is
7 still held within the elongate clamping means of the
8 machine for stretching a rectangular sheet of
9 plastic.

10
11 9. A machine for stretching and vacuum forming a
12 rectangular sheet of plastic as claimed in Claim 8,
13 the machine having a means for selectively cooling
14 zones of the plastic sheet held therein.

15
16
17 10. A method of stretching a rectangular sheet of
18 plastic material, the method comprising the steps
19 of:

20
21 (a) engagably holding the sides of said sheet; and
22 (b) stretching said sheet along a first axis of said
23 sheet whilst holding the sides of said sheet
24 parallel to the first axis so as to allow the sheet
25 to stretch proportionately along the first axis but
26 so as to resist deformation of the sides of said
27 sheet orthogonal to the first axis.

28
29 11. A method of stretching a rectangular sheet of
30 plastic material as claimed in Claim 10, the method
31 further having the step of:

32
33 (c) stretching said sheet along a second axis of
34 said sheet whilst holding the sides of said sheet

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1 parallel to the second axis so as to allow the sheet
2 to stretch proportionately along the second axis but
3 so as to resist deformation of the sides of said
4 sheet orthogonal to the second axis, the second axis
5 being orthogonal to the first axis.
6

7 12. A method of stretching a rectangular sheet of
8 plastic material as claimed in Claim 10, the method
9 involving, simultaneous to stretching said sheet
10 parallel to a first axis, also stretching said sheet
11 along a second axis of said sheet whilst holding the
12 sides of said sheet parallel to the second axis so
13 as to allow the sheet to stretch proportionately
14 along the second axis but so as to resist
15 deformation of the sides of said sheet orthogonal to
16 the second axis, the second axis being orthogonal to
17 the first axis.
18

19 13. A method of stretching a rectangular sheet of
20 plastic material as claimed in any of claims 10 to
21 12, wherein the sides of said sheet are engageably
22 held by a first and second orthogonal pairs of
23 elongate clamping means which each engagably
24 cooperate with a side of said sheet through a
25 plurality of secondary clamps.
26

27 14. A method of stretching a rectangular sheet of
28 plastic material as claimed in Claim 13 wherein the
29 secondary clamps are adapted to move along the
30 length of the clamping means proportionately to the
31 stretching of the sheet along an axis parallel to
32 the clamping means.
33

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1 15. A method of stretching a rectangular sheet of
2 plastic material as claimed in Claim 14 wherein the
3 secondary clamps wherein the secondary clamps are
4 moved along the length of the elongate clamping
5 means by the motion of the sheet.
6

7 16. A method of stretching a rectangular sheet of
8 plastic material as claimed in any of Claims 10 to
9 15, the method having the step of heating the sheet
10 of plastic material.
11

12 17. A method of stretching and vacuum forming a
13 rectangular sheet of plastic material comprising the
14 steps of stretching a rectangular sheet of plastic
15 according to a method as claimed in any of Claims 10
16 to 16 and then vacuum forming said stretched sheet
17 of plastic.
18

19 18. A method of stretching and vacuum forming a
20 rectangular sheet of plastic material as claimed in
21 Claim 17 wherein the edges of said sheet are
22 engagably held by a plurality of primary clamping
23 means before vacuum forming.
24

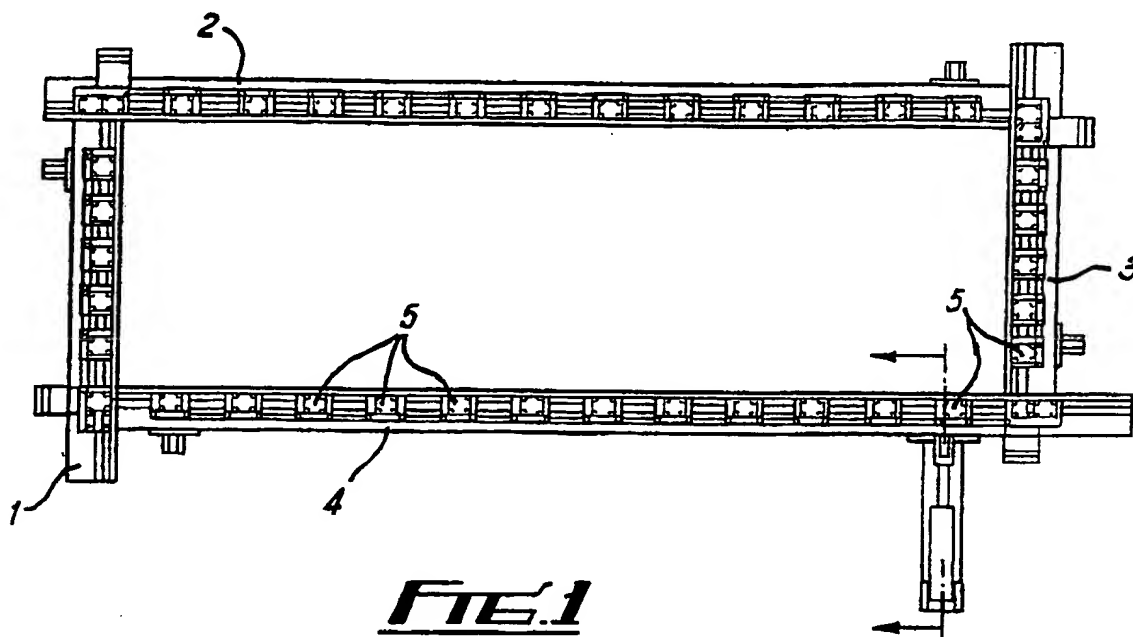
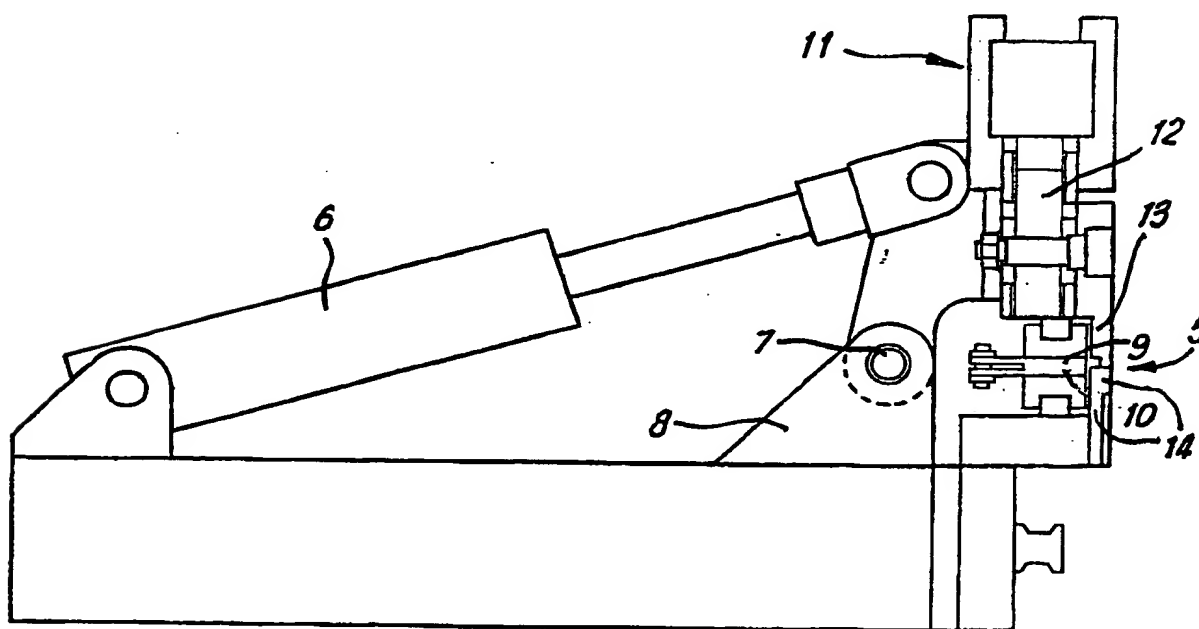
25 19. A method of stretching and vacuum forming a
26 rectangular sheet of plastic material as claimed in
27 Claim 17 or Claim 18 wherein zones of the plastic
28 material are selectively cooled.

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**FIG 1****FIG 2**

SUBSTITUTE SHEET (RULE 26)

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PCT/GB99/04391

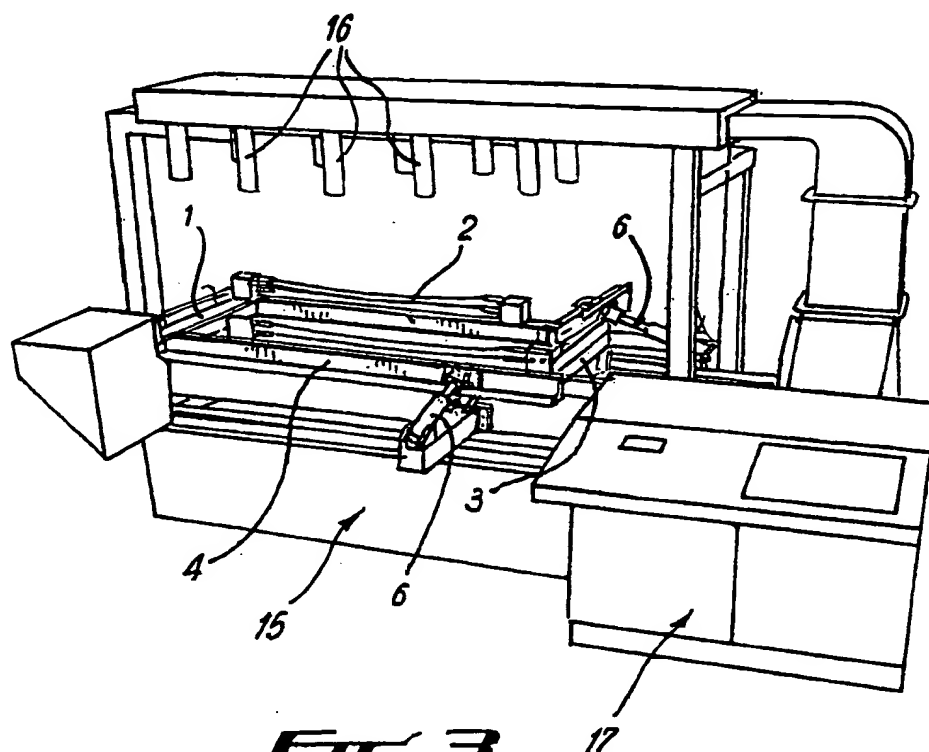


FIG. 3

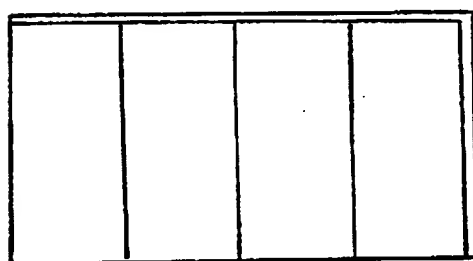
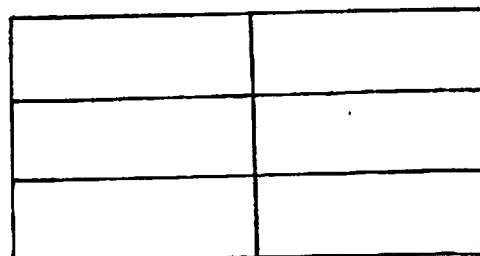


FIG. 5a

FIG. 5b



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Material 10		
Sample Number	N.C.I.S @ 23°C (kJ / m ²)	Flexural Modulus (MPa)
1	87	1250
2	85	1240
3	85	1250
4	83	1280
5	88	1250
6	85	---
7	88	---
8	84	---
9	84	---
10	86	---
mean	85	1250
σ_{n-1}	1.2	7

Material 12		
Sample Number	N.C.I.S @ 23°C (kJ / m ²)	Flexural Modulus (MPa)
1	NB	1340
2	NB	1380
3	NB	1370
4	NB	1410
5	NB	1400
6	NB	---
7	83	---
8	NB	---
9	NB	---
10	NB	---
mean	N/A	1380
σ_{n-1}	N/A	28

FIG. 4

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference pre.683.pct.nmck	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 99/ 04391	International filing date (day/month/year) 30/12/1999	(Earliest) Priority Date (day/month/year) 31/12/1998
Applicant PRESTON ASSOCIATES (SCOTLAND) LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing:



contained in the international application in written form.



filed together with the international application in computer readable form.



furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of Invention is lacking (see Box II).

4. With regard to the title,

the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the abstract,

the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.

1

None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 99/04391

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B29C55/12 B29C51/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 579 718 A (MILLER HAROLD A ET AL) 25 May 1971 (1971-05-25) column 3, line 40 - line 69; figure 1	1-7, 10-16
X	US 3 635 640 A (WOOD EDWARD C) 18 January 1972 (1972-01-18) column 2, line 41 - line 75; figure 1	1-7, 10-16
A	DATABASE WPI Section Ch, Week 198033 Derwent Publications Ltd., London, GB; Class A32, AN 1980-58326C XP002135276 -& SU 706 249 A (SUBBOTIN A N), 30 December 1979 (1979-12-30) abstract; figure --- -/--	1-7, 10-16

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

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- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

10 April 2000

Date of mailing of the international search report

20/04/2000

Name and mailing address of the ISA

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NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3018

Authorized officer

Attalla, G

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/04391

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 475 (M-774), 13 December 1988 (1988-12-13) -& JP 63 197626 A (SINTOKOGIO LTD), 16 August 1988 (1988-08-16) abstract; figure 1	8,17,18
A	PATENT ABSTRACTS OF JAPAN vol. 009, no. 183 (M-400), 30 July 1985 (1985-07-30) -& JP 60 049921 A (TOYOTA JIDOSHA KK), 19 March 1985 (1985-03-19) abstract; figures 1,2	8,17,18
A	EP 0 623 449 A (GEISS GEORG MASCHF) 9 November 1994 (1994-11-09) claims 1,2	8,17,18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 99/04391

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3579718 A	25-05-1971	GB 1247617 A	29-09-1971
US 3635640 A	18-01-1972	GB 1247618 A	29-09-1971
SU 706249 A	30-12-1979	NONE	
JP 63197626 A	16-08-1988	NONE	
JP 60049921 A	19-03-1985	NONE	
EP 0623449 A	09-11-1994	DE 4314641 A	09-02-1995
		AT 167824 T	15-07-1998
		DE 59406352 D	06-08-1998
		ES 2120533 T	01-11-1998

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference (if desired) (12 characters maximum) pre.683.pct.nmck

Box No. I TITLE OF INVENTION	
Plastic stretching method and apparatus for use in vacuum forming techniques	
Box No. II APPLICANT	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)	
Preston Associates (Scotland) Limited 4 North Approach Road KINCARDINE ON FORTH FK10 4NH United Kingdom	<input type="checkbox"/> This person is also inventor. Telephone No. Facsimile No. Teleprinter No.
State (that is, country) of nationality: United Kingdom	State (that is, country) of residence: United Kingdom
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input checked="" type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)	
Preston, Iain 4 North Approach Road KINCARDINE ON FORTH FK10 4NH United Kingdom	This person is: <input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)
State (that is, country) of nationality: United Kingdom	State (that is, country) of residence: United Kingdom
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
<input checked="" type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet.	
Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE	
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: <input checked="" type="checkbox"/> agent <input type="checkbox"/> common representative	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)	
Kennedy & Co. Floor 4, Queens House 29 St Vincent Place GLASGOW G1 2DT United Kingdom	Telephone No. 0141 226 6826 Facsimile No. 0141 226 6838 Teleprinter No.
<input type="checkbox"/> Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.	

Sheet No. 2

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

Hall, Gordon
4 North Approach Road
KINCARDINE ON FORTH
FK10 4NH
United Kingdom

This person is:

- ☐ applicant only
☒ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:
United Kingdom

State (that is, country) of residence:
United Kingdom

This person is applicant for the purposes of:

☐ all designated States☐ all designated States except the United States of America☒ the United States of America only☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

☐ all designated States☐ all designated States except the United States of America☐ the United States of America only☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

☐ all designated States☐ all designated States except the United States of America☐ the United States of America only☐ the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of:

☐ all designated States☐ all designated States except the United States of America☐ the United States of America only☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Sheet No. 3

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

Regional Patent

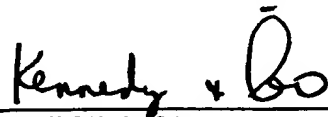
- ☒ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

National Patent (if other kind of protection or treatment desired, specify on dotted line):

- | | |
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| <input checked="" type="checkbox"/> AE United Arab Emirates | <input checked="" type="checkbox"/> LR Liberia |
| <input checked="" type="checkbox"/> AL Albania | <input checked="" type="checkbox"/> LS Lesotho |
| <input checked="" type="checkbox"/> AM Armenia | <input checked="" type="checkbox"/> LT Lithuania |
| <input checked="" type="checkbox"/> AT Austria | <input checked="" type="checkbox"/> LU Luxembourg |
| <input checked="" type="checkbox"/> AU Australia | <input checked="" type="checkbox"/> LV Latvia |
| <input checked="" type="checkbox"/> AZ Azerbaijan | <input checked="" type="checkbox"/> MD Republic of Moldova |
| <input checked="" type="checkbox"/> BA Bosnia and Herzegovina | <input checked="" type="checkbox"/> MG Madagascar |
| <input checked="" type="checkbox"/> BB Barbados | <input checked="" type="checkbox"/> MK The former Yugoslav Republic of Macedonia |
| <input checked="" type="checkbox"/> BG Bulgaria | |
| <input checked="" type="checkbox"/> BR Brazil | <input checked="" type="checkbox"/> MN Mongolia |
| <input checked="" type="checkbox"/> BY Belarus | <input checked="" type="checkbox"/> MW Malawi |
| <input checked="" type="checkbox"/> CA Canada | <input checked="" type="checkbox"/> MX Mexico |
| <input checked="" type="checkbox"/> CH and LI Switzerland and Liechtenstein | <input checked="" type="checkbox"/> NO Norway |
| <input checked="" type="checkbox"/> CN China | <input checked="" type="checkbox"/> NZ New Zealand |
| <input checked="" type="checkbox"/> CU Cuba | <input checked="" type="checkbox"/> PL Poland |
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| <input checked="" type="checkbox"/> DE Germany | <input checked="" type="checkbox"/> RO Romania |
| <input checked="" type="checkbox"/> DK Denmark | <input checked="" type="checkbox"/> RU Russian Federation |
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| <input checked="" type="checkbox"/> GE Georgia | <input checked="" type="checkbox"/> SL Sierra Leone |
| <input checked="" type="checkbox"/> GH Ghana | <input checked="" type="checkbox"/> TJ Tajikistan |
| <input checked="" type="checkbox"/> GM Gambia | <input checked="" type="checkbox"/> TM Turkmenistan |
| <input checked="" type="checkbox"/> HR Croatia | <input checked="" type="checkbox"/> TR Turkey |
| <input checked="" type="checkbox"/> HU Hungary | <input checked="" type="checkbox"/> TT Trinidad and Tobago |
| <input checked="" type="checkbox"/> ID Indonesia | <input checked="" type="checkbox"/> UA Ukraine |
| <input checked="" type="checkbox"/> IL Israel | <input checked="" type="checkbox"/> UG Uganda |
| <input checked="" type="checkbox"/> IN India | <input checked="" type="checkbox"/> US United States of America |
| <input checked="" type="checkbox"/> IS Iceland | |
| <input checked="" type="checkbox"/> JP Japan | <input checked="" type="checkbox"/> UZ Uzbekistan |
| <input checked="" type="checkbox"/> KE Kenya | <input checked="" type="checkbox"/> VN Viet Nam |
| <input checked="" type="checkbox"/> KG Kyrgyzstan | <input checked="" type="checkbox"/> YU Yugoslavia |
| <input checked="" type="checkbox"/> KP Democratic People's Republic of Korea | <input checked="" type="checkbox"/> ZA South Africa |
| | <input checked="" type="checkbox"/> ZW Zimbabwe |
| <input checked="" type="checkbox"/> KR Republic of Korea | Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet: |
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| <input checked="" type="checkbox"/> LK Sri Lanka | |

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

Sheet No. ...4...

Box No. VI PRIORITY CLAIM		<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box.		
Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country	regional application:* regional Office	international application: receiving Office
item (1) 31 December 1998	9828820.2	UK		
item (2) 28 October 1999	9925486.4	UK		
item (3)				
<input checked="" type="checkbox"/> The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): <u>1 and 2</u>				
<small>* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.</small>				
Box No. VII INTERNATIONAL SEARCHING AUTHORITY				
Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used): ISA/		Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority): Date (day/month/year) Number Country (or regional Office)		
Box No. VIII CHECK LIST; LANGUAGE OF FILING				
This international application contains the following number of sheets: request : 4 description (excluding sequence listing part) : 11 claims : 5 abstract : 1 drawings : 5 sequence listing part of description : Total number of sheets : 26		This international application is accompanied by the item(s) marked below: 1. <input checked="" type="checkbox"/> fee calculation sheet 2. <input type="checkbox"/> separate signed power of attorney 3. <input type="checkbox"/> copy of general power of attorney, reference number, if any: 4. <input type="checkbox"/> statement explaining lack of signature 5. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s): 6. <input type="checkbox"/> translation of international application into (language): 7. <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material 8. <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form 9. <input type="checkbox"/> other (specify):		
Figure of the drawings which should accompany the abstract:		Language of filing of the international application:		
Box No. IX SIGNATURE OF APPLICANT OR AGENT				
Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).				
 KENNEDY & CO.				

For receiving Office use only	
1. Date of actual receipt of the purported international application: 3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application: 4. Date of timely receipt of the required corrections under PCT Article 11(2): 5. International Searching Authority (if two or more are competent): ISA/	2. Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received: 6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid.

For International Bureau use only
Date of receipt of the record copy by the International Bureau:

This sheet is not part of and does not count as a sheet of the international application.

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FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International application No.

Applicant's or agent's
file reference

pre.683.pct.nmck

Date stamp of the receiving Office

Applicant

Preston Associates (Scotland) Limited

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE £55.00 T

2. SEARCH FEE £638.00 S

International search to be carried out by

(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

The international application contains 26 sheets.

first 30 sheets £285.00 b1

remaining sheets x additional amount - b2

Add amounts entered at b1 and b2 and enter total at B £285.00 B

Designation Fees

The international application contains designations.

10 x £65.00 = £650.00 D

number of designation fees payable (maximum: 10) amount of designation fee

Add amounts entered at B and D and enter total at I £935.00 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

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5. TOTAL FEES PAYABLE £1672.00

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TOTAL

☒ The designation fees are not paid at this time.

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☐ (this check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit) is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

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Signature

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference pre.683.pct.nm2B		FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB99/04391	International filing date (day/month/year) 30/12/1999	Priority date (day/month/year) 31/12/1998
International Patent Classification (IPC) or national classification and IPC B29C55/12		
Applicant PRESTON ASSOCIATES (SCOTLAND) LIMITED et al.		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 17 sheets.</p>		
<p>3. This report contains Indications relating to the following items:</p> <ul style="list-style-type: none"> I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input type="checkbox"/> Certain defects in the international application VIII <input checked="" type="checkbox"/> Certain observations on the international application 		
Date of submission of the demand 22/07/2000		Date of completion of this report 05.04.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465		Authorized officer Grenier, A Telephone No. +49 89 2399 2983 

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB99/04391

I. Basis of the report

1. With regard to the elements of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17):*

Description, pages:

1-12 as received on 23/01/2001 with letter of 18/01/2001

Claims, No.:

1-14 as received on 23/01/2001 with letter of 18/01/2001

Drawings, sheets:

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB99/04391

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. Statement**

Novelty (N)	Yes:	Claims	1-14
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-14
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-14
	No:	Claims	

2. Citations and explanations
see separate sheet

VIII. Certain observations on the International application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB99/04391

Re Item V**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. The prior art documents US-A-3 579 718 and US-A-3 635 640 disclose machines for stretching sheets of material where there are elongate clamping means which comprise a plurality of movable clamping means to allow movement of the clamps during stretching and thereby avoid scalloping of the sheet.
- 1.2. However, a machine and a method additionally involving fixed clamping means to fixedly hold the sides of the stretched sheet for additionally providing vacuum forming of said sheet, as defined in the independent claims 1 and 8, are neither shown nor suggested in the available prior art.
The above combination of features appears to be a non-obvious solution for a quality enhancing and time and cost saving integrated stretching and moulding process.
2. Consequently, independent apparatus claim 1 and independent method claim 8, as well as claims 2 to 7 and 9 to 14, which are dependent respectively from claims 1 and 8, fulfil the requirements of novelty and inventive step according to Article 33 (1),(2),(3) PCT.
3. All the claims clearly fulfil the requirement of industrial application according to Article 33 (1),(4) PCT.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB99/04391

Re Item VIII

Certain observations on the international application

1. The two part form of claim 1 presents new features in the preamble (e.g. the combination of primary and secondary clamping means), whereas the characterizing part contains already known features (e.g. the movable secondary clamping means in operation).
Consequently, the present formulation of claim 1 is unclear.
 - 1.1. Moreover, the two part form of claim 1 does not appear appropriate in view of the difficulty to concisely and clearly distinguish the prior art features from the new features.
 - 1.2. In order to overcome the above objection, claim 1 should have been drafted in the one part form.
2. The description is not in conformity with the claims as required by Rule 5.1(a)(iii) PCT.

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1

1 PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM
2 FORMING TECHNIQUES

3

4 The present invention relates in general to technology
5 for stretching plastic sheets. In particular, the
6 invention relates to the stretching of plastic sheets as
7 a preparation step for use with vacuum forming
8 techniques.

9

10 Vacuum forming techniques are used in a variety of
11 industries; for example, bathroom furnishings such as
12 baths can be vacuum formed from a single sheet of
13 thermoplastic material. The thermoplastic material most
14 commonly used for vacuum forming bathroom furnishings at
15 the present time is acrylic.

16

17 In this manufacturing process, the cost of the
18 thermoplastic sheet represents approximately 70% of the
19 manufacturer's final costs. It would therefore be
20 beneficial to find a method of using less thermoplastic
21 in the manufacturing process. However, if one simply
22 used a thinner sheet, one would expect to produce a final
23 product with reduced mechanical strength.

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1 It is therefore an aim of the present invention to
2 provide a method and apparatus for producing vacuum
3 formed goods that uses less thermoplastic than
4 conventional techniques whilst retaining, or even
5 improving, mechanical strength.

6

7 We have found that a thermoplastic sheet, such as an
8 acrylic sheet, which has been stretched before vacuum
9 forming provides a final product which has greater
10 mechanical strength than an unstretched sheet which has
11 the same thickness at the start of the vacuum forming
12 step.

13

14 However, when one considers how to implement this
15 stretching step industrially, a technical difficulty
16 becomes apparent. When a plastic sheet is stretched it
17 will scallop, that is to say that it will narrow in the
18 middle with the sides bowing inwards. This means that it
19 will not have a constant width and thickness throughout
20 and cannot be cut efficiently into smaller square or
21 rectangular portions.

22

23 For example, US Patent No. 5,271,352 to Critical Sciences
24 (Australia) Limited discloses a plastic stretching device
25 for use in vacuum forming boat hulls. This device pulls
26 plastic apart without any means for preventing
27 scalloping. It is therefore impractical to use for any
28 significant amount of stretching.

29

30 PCT/US92/07408 describes a plastic stretching device
31 which has movable clamping means holding all sides of a
32 plastic sheet. However, the edges of the plastic sheet
33 would be unable to expand with the material as a whole,
34 distorting its shape.

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1
2 JP60049921 to Toyota Jidosha KK goes part of the way to
3 solving this problem by having a plurality of clamps
4 along at least one side of a plastic sheet. However, the
5 movement of each clamps needs individually controlled,
6 leading to a complex and expensive machine.

7
8 US3579718 describes an apparatus for stretching sheets of
9 material where there are elongate clamping means which
10 comprise a plurality of movable clamping means. However,
11 although this allows movement of the clamps during
12 stretching, there is no facility to then hold the
13 stretched sheet in place to allow subsequent vacuum
14 forming.

15
16 Similarly, US3635640 describes arrangements and methods
17 where the apparatus of US3579718 may be used.

18
19 In JP63197626 to Shinto Kogyo KK, a plurality of clamps
20 along opposite sides of a sheet of plastic are controlled
21 automatically by their being mounted on endless roller
22 chains which function to move the sheet of plastic into
23 and out of a heating means as well as holding the plastic
24 sheet. However, when material is stretched by this
25 machine moving the two roller chains apart, the material
26 edges held by the chains are unable to contract
27 proportionately, leading to distortion of the edges and
28 scalloping of the sheet as a whole.

29
30 The aim of this invention is therefore to provide a
31 method of stretching plastic sheets which can be used to
32 expand the total surface area of the sheet without
33 distorting the sheet, wasting material or having a non-
34 uniform thickness. In particular, the invention aims to

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1 provide a simple controllable mechanism. Furthermore,
2 this invention aims to stretch the plastic sheet in a
3 manner adapted for immediate use in vacuum forming to
4 gain the strength enhancing benefits of the stretching
5 step.

6

7 In this application, the term "plastic" refers to any
8 thermoplastic material.

9

10 According to a first aspect of the present invention
11 there is provided a machine for stretching a rectangular
12 sheet of plastic material, the machine having a first and
13 second orthogonal pairs of opposed elongate clamping
14 means which engagably cooperate with the sides of said
15 sheet and thereby hold said sheet, the machine including
16 a means to controllably urge apart a first pair of
17 opposed elongate clamping means and thereby stretch a
18 sheet held therebetween characterized in that the second
19 pair of opposed elongate clamping means is adapted to
20 allow said sheet to stretch uniformly in a direction
21 parallel to the lengths of the second pair of elongate
22 clamping means whilst resisting movement of the clamped
23 sides of the sheet in a direction orthogonal to the
24 lengths of the second pair of elongate clamping means.

25

26 Preferably, the machine includes means to controllably
27 urge apart both pairs of opposed clamping means and
28 thereby stretch a sheet held therein in two dimensions,
29 each elongate clamping means being adapted to allow said
30 sheet to stretch uniformly in a direction parallel to the
31 length of said individual elongate clamping means whilst
32 resisting movement of the side of the rectangular sheet
33 clamped by said individual elongate clamping means in a

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1 direction orthogonal to the length of said individual
2 elongate clamping means.

3

4 The machine may be adapted to stretch the sheet first in
5 one direction and then subsequently in a second direction
6 orthogonal to the first direction.

7

8 Preferably, the elongate clamping means having a
9 plurality of secondary clamps distributed along their
10 length, the secondary clamps engagably clamping a portion
11 of the edge of the rectangular sheet of plastic and being
12 adapted to move along the length of the elongate clamping
13 means proportionately to the stretching of the sheet
14 parallel to the length of the clamping means.

15

16 More preferably, the secondary clamps are moved along the
17 length of the elongate clamping means by the motion of
18 the sheet.

19

20 Preferably, the clamping means have a primary clamping
21 means which engageably and fixedly clamps a side of the
22 sheet of the plastic material.

23

24 Preferably also, the machine has a heating means for
25 evenly heating a plastic sheet held therein.

26

27 According to a second aspect of the present invention
28 there is provided a machine for stretching and vacuum
29 forming a rectangular sheet of plastic comprising a
30 machine for stretching a rectangular sheet of plastic as
31 claimed in any preceding Claim and an engagable vacuum
32 forming means, wherein the engagable vacuum forming means
33 is adapted to vacuum form a rectangular sheet of plastic
34 stretched by the machine for stretching a rectangular

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6

1 sheet of plastic whilst said rectangular sheet of plastic
2 is still held within the elongate clamping means of the
3 machine for stretching a rectangular sheet of plastic.

4

5 Preferably, the machine has a means for selectively
6 cooling zones of the plastic sheet held therein.

7

8 According to a third aspect of the present invention,
9 there is provided a method of stretching a rectangular
10 sheet of plastic material, the method comprising the
11 steps of:

12

13 (a) engagably holding the sides of said sheet; and
14 (b) stretching said sheet along a first axis of said
15 sheet whilst holding the sides of said sheet
16 parallel to the first axis so as to allow the sheet
17 to stretch proportionately along the first axis but
18 so as to resist deformation of the sides of said
19 sheet orthogonal to the first axis.

20

21 Preferably, the method further has the step of:

22 (c) stretching said sheet along a second axis of
23 said sheet whilst holding the sides of said sheet
24 parallel to the second axis so as to allow the sheet
25 to stretch proportionately along the second axis but
26 so as to resist deformation of the sides of said
27 sheet orthogonal to the second axis, the second axis
28 being orthogonal to the first axis.

29

30 Preferably, the method involves, simultaneous to
31 stretching said sheet parallel to a first axis, also
32 stretching said sheet along a second axis of said sheet
33 whilst holding the sides of said sheet parallel to the
34 second axis so as to allow the sheet to stretch

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7

1 proportionately along the second axis but so as to resist
2 deformation of the sides of said sheet orthogonal to the
3 second axis, the second axis being orthogonal to the
4 first axis.

5

6 Preferably, the sides of said sheet are engageably held
7 by a first and second orthogonal pairs of elongate
8 clamping means which each engagably cooperate with a side
9 of said sheet through a plurality of secondary clamps.

10

11 Preferably also, the secondary clamps are adapted to move
12 along the length of the clamping means proportionately to
13 the stretching of the sheet along an axis parallel to the
14 clamping means.

15

16 Most preferably, the secondary clamps wherein the
17 secondary clamps are moved along the length of the
18 elongate clamping means by the motion of the sheet.

19

20 Typically, the method will have the step of heating the
21 sheet of plastic material.

22

23 According to a fourth aspect of the present invention,
24 there is provided a method of stretching and vacuum
25 forming a rectangular sheet of plastic material
26 comprising the steps of stretching a rectangular sheet of
27 plastic according to a method as claimed in any of Claims
28 10 to 16 and then vacuum forming said stretched sheet of
29 plastic.

30

31 Preferably, the edges of said sheet are engagably held by
32 a plurality of primary clamping means before vacuum
33 forming.

34

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1 Zones of the plastic material may be selectively cooled.

2

3 An example embodiment of the present invention will now
4 be illustrated with reference to the following figures in
5 which:

6 Figure 1 is a plan view of a plastic sheet
7 stretching machine;

8 Figure 2 is a cross-section through a plastic
9 stretching machine along line AA;

10 Figure 3 is a perspective view of a plastic
11 stretching machine according to the present
12 invention;

13 Figure 4 is a table of results from a Notched Charpy
14 Impact Strength test performed to BS EN ISO 179/1eA-
15 1997; and

16 Figure 5 shows a plan for cutting up sheets of
17 material in a conventional fashion and in a fashion
18 for use with the present invention.

19

20 A plastic stretching machine shown in plan view in Figure
21 1 is intended for use with a rectangular sheet of plastic
22 material or any other vacuum formable material. Elongate
23 clamping means are provided in the form of four clamping
24 bars (1 to 4), one to clamp each edge of the rectangular
25 plastic sheet. Clamping bars 1 and 3 oppose each other,
26 as do clamping bars 2 and 4. Clamping bars 1 and 2 are
27 fixed in place, whereas clamping bars 3 and 4 may be
28 moved, as controlled by a programmable logic controller.

29

30 Each clamping bar 1, 2, 3 and 4 comprises a plurality of
31 secondary clamping means 5 (only some of which are
32 labelled in Figure 1). These clamping means are mounted
33 upon each clamp bar and may move along its length with a
34 low co-efficient of friction.

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1

2 A rectangular hot thermoplastic sheet is placed within
3 the device and is clamped around its four edges by the
4 secondary clamps 5. This apparatus is shown in cross-
5 section along line AA in Figure 2. The machine may also
6 have means to itself heat the sheet and/or keep the sheet
7 hot.

8

9 Actuator 6 (one shown in detail as an example) activates
10 the clamping mechanism. This causes the clamping head to
11 be rotated around joint 7 on support assembly 8 and the
12 plastic sheet is held in the secondary clamps 5 between
13 plates 9 and 10. Alternate pairs of clamp bars are then
14 pulled apart. For example, whilst clamp bar 1 is held in
15 place, clamp bar 3 may be moved away from it, stretching
16 the plastic sheet in the longitudinal direction. Clamp
17 bars 2 and 4 do not move. However, the secondary clamps
18 5 are free to move along the clamp bars. They are pulled
19 along by the material sheet and therefore move
20 proportionately to the movement of clamp bar 3. They act
21 to resist scalloping of the plastic sheet.

22

23 Similarly, clamp bar 4 can be moved away from clamp bar
24 2, whilst clamp bar 1 and clamp bar 3 remain in place.
25 Again, the clamping means move proportionately to the
26 stretching of the sheet cause by movement in clamping bar
27 4 and prevent scalloping. In order for this to work
28 there has to be very low friction preventing the movement
29 of the secondary clamping means.

30

31 Once the stretching phase has been completed, an actuator
32 11 acting through a thrust pin 12 engages a primary
33 clamping means which is provided on each clamped set and
34 comprises a top plate 13 and bottom plate 14 within which

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1 the plastic sheet is securely held. All four sides are
2 held at once.

3
4 A mould is then driven up through the clamped sheet
5 forming a seal. The mould is then vacuumed by
6 conventional means to form the resulting mould. At the
7 end of this complete product cycle the secondary clamp
8 carriages 5 are returned to their initial positions by
9 the action of the primary clamp bars. A series of
10 linkages prevent the secondary clamps 5 from getting too
11 close to each other.

12
13 Figure 4 shows a perspective view of the combined
14 stretching and vacuum forming machine. In this Figure,
15 conventional vacuum forming apparatus 15 is provided
16 underneath the stretching apparatus. The machine also
17 provides zoned cooling for control of thickness
18 distribution in the final product. This is a technique
19 used in the prior art and cooling apparatus 16 is mounted
20 above the stretching apparatus. An electronic controller
21 17 is provided to allow automation of the procedure.

22
23 The entire process cycle involving both the timings and
24 movements is controlled by a computer or controlled
25 programme logic controller. As a result of this machine
26 it becomes possible to make considerable savings in raw
27 material costs; for example, experiments have indicated
28 that savings of 30% - 50% can be readily achieved. This
29 could not be achieved simply by vacuum forming a thinner
30 sheet of thermoplastic as only the strength benefits
31 provided by the stretching step allow this lower volume
32 of plastic to be used.

33

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11

1 Figure 4 shows a table of results from a Notched Charpy
2 Impact Strength (N.C.I.S.) test performed to BS EN ISO
3 179/1eA - 1997 on samples of 5mm Acrylate Capped ABS
4 taken through the above process.

5

6 In this table, Flexural Modulus tests were performed to
7 BS EN ISO 178 - 1997 at a test speed of 2mm/min. Sample
8 10 test bars were nominally 4mm thick x 10mm wide.
9 Sample 12 test bars nominally 2.3mm thick x 15mm wide.
10 Fallen Ball. All Notched Charpy samples that gave a
11 valid result exhibited a partial break type.

12

13 Figure 5 (a) shows a conventional method for cutting up a
14 sheet of plastic that is 3100mm x 1800mm to form four
15 rectangular pieces 1750mm x 750mm for use in making a
16 product sized 1700mm x 700mm. Note that offcuts are left
17 around the edge. Figure 5 (b) shows how this same sheet
18 can be cut into six rectangular pieces 1550mm x 600mm
19 without offcuts, that may be stretched then used to give
20 a product sized 1700mm x 700mm as before.

21

22 This reduces the time required and the space requirements
23 for storing raw material. Additionally, fewer different
24 sizes of sheet will have to be stocked by a manufacturer.
25 These benefits represent a substantial cut in the cost of
26 manufacturing the product, therefore providing an
27 important commercial advantage.

28

29 It will be clear to one skilled in the art that this
30 technique can be used with acrylic plastic or any other
31 vacuum formable material. Furthermore, this plastic
32 stretching technique will find applications in areas
33 other than just vacuum forming.

34

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1 Further modifications and improvements may be
2 incorporated without departing from the scope of the
3 invention herein described.
4
5 Throughout this application, unless the context requires
6 otherwise, the word "comprise" or variations such as
7 "comprises" or "comprising" will be understood to imply
8 the inclusion of a stated integer or group of integers
9 but not the exclusion of any other integer or group of
10 integers.

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1 AMENDED CLAIMS

2

3 1. A machine for stretching and vacuum forming a
4 rectangular sheet of plastic material, the machine
5 having a first and second orthogonal pairs of
6 opposed elongate clamping means (1-4) which
7 engagably co-operate with the sides of said sheet
8 and thereby hold said sheet, wherein the elongate
9 clamping means (1-4) comprise primary clamping means
10 (13,14) and secondary (5) clamping means, with the
11 primary clamping means (13,14) engagably and fixedly
12 clamping a side of the sheet of the plastic material
13 and the secondary clamping means (5) engagably
14 clamping a portion of the edge of the rectangular
15 sheet of plastic and being adapted to move along the
16 length of the elongate clamping means (1-4), the
17 machine including a means to controllably urge apart
18 a first pair of opposed elongate clamping means (1
19 and 3) and thereby stretch a sheet held therebetween
20 characterised in that the second pair of opposed
21 elongate clamping means (2 and 4) uses the movable
22 secondary clamping means (5) to allow said sheet to
23 stretch uniformly in a direction parallel to the
24 lengths of the second pair of elongate clamping
25 means (2 and 4) whilst resisting movement of the
26 clamped sides of the sheet in a direction orthogonal
27 to the lengths of the second pair of elongate
28 clamping means (2 and 4), and once the plastic sheet
29 has been stretched the fixed primary clamping means
30 (13,14) are then used to hold the plastic sheet in a
31 fixed position during the vacuum forming process.

32

33 2. A machine for stretching and vacuum forming a
34 rectangular sheet of plastic material as Claimed in

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14

Claim 1, the machine including means to controllably urge apart both pairs of opposed elongate clamping means (1-4) and thereby stretch a sheet held therein in two dimensions, each elongate clamping means (1-4) using the secondary clamping means (5) to allow said sheet to stretch uniformly in a direction parallel to the length of said individual elongate clamping means (1-4) whilst resisting movement of the side of the rectangular sheet clamped by said individual elongate clamping means (1-4) in a direction orthogonal to the length of said individual elongate clamping means (1-4).

3. A machine for stretching and vacuum forming a rectangular sheet of plastic material as Claimed in Claim 1 or Claim 2, the machine being adapted to stretch the sheet first in one direction and then subsequently in a second direction orthogonal to the first direction.

4. A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in any of the previous Claims, wherein the secondary clamps are moved along the length of the elongate clamping means by the motion of the sheet.

5. A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in any preceding Claim, the machine having a heating means for evenly heating a plastic sheet held therein.

6. A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in any preceding Claim, wherein the vacuum forming means is

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1 engagable and adapted to vacuum form a rectangular
2 sheet of plastic stretched by the machine for
3 stretching a rectangular sheet of plastic whilst
4 said rectangular sheet of plastic is still held
5 within the elongate clamping means (1-4) of the
6 machine by the primary fixed clamping means (13,14).

7
8 7. A machine for stretching and vacuum forming a
9 rectangular sheet of plastic as claimed in any
10 preceding Claim, the machine having a means for
11 selectively cooling zones of the plastic sheet held
12 therein.

13
14 8. A method of stretching and vacuum forming a
15 rectangular sheet of plastic material, the method
16 comprising the steps of:
17 (a) engagably holding the sides of said sheet using
18 movable clamping means (5); and
19 (b)(i) stretching said sheet along a first axis of
20 said sheet whilst holding the sides of said sheet
21 parallel to the first axis so as to allow the sheet
22 to stretch proportionately along the first axis but
23 so as to resist deformation of the sides of said
24 sheet orthogonal to the first axis; and
25 (c) fixedly holding the sides of said stretched
26 sheet using fixed clamping means; and
27 (d) vacuum forming said stretched sheet.

28
29 9. A method of stretching and vacuum forming a
30 rectangular sheet of plastic material as claimed in
31 Claim 8, the method further having the step of:
32
33 (b)(ii) stretching said sheet along a second axis of
34 said sheet whilst holding the sides of said sheet

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16

1 parallel to the second axis so as to allow the sheet
2 to stretch proportionately along the second axis but
3 so as to resist deformation of the sides of said
4 sheet orthogonal to the second axis, the second axis
5 being orthogonal to the first axis.

6

7 10. A method of stretching and vacuum forming a
8 rectangular sheet of plastic material as claimed in
9 Claim 8, the method involving, simultaneous to
10 stretching said sheet parallel to a first axis, also
11 stretching said sheet along a second axis of said
12 sheet whilst holding the sides of said sheet
13 parallel to the second axis so as to allow the sheet
14 to stretch proportionately along the second axis but
15 so as to resist deformation of the sides of said
16 sheet orthogonal to the second axis, the second axis
17 being orthogonal to the first axis.

18

19 11. A method of stretching and vacuum forming a
20 rectangular sheet of plastic material as claimed in
21 Claim 8 wherein the secondary clamps are adapted to
22 move along the length of the elongate clamping means
23 (1-4) proportionately to the stretching of the sheet
24 along an axis parallel to the clamping means.

25

26 12. A method of stretching and vacuum forming a
27 rectangular sheet of plastic material as claimed in
28 Claim 11 wherein the secondary clamps are moved
29 along the length of the elongate clamping (1-4)
30 means by the motion of the sheet.

31

32 13. A method of stretching and vacuum forming a
33 rectangular sheet of plastic material as claimed in

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17

- 1 any of Claims 8 to 12, the method having the step of
- 2 heating the sheet of plastic material.
- 3
- 4 14. A method of stretching and vacuum forming a
- 5 rectangular sheet of plastic material as claimed in
- 6 Claim 8 or Claim 13 wherein zones of the plastic
- 7 material are selectively cooled.